



Technology Acceptance, Actual Use, and Learning Outcomes in AI-Assisted Music Teaching: Evidence from Chinese University Students

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Abstract: The objectives of this research were (1) to examine the influence of facilitating conditions and perceived ease of use on perceived usefulness and students' attitudes toward AI-assisted music teaching, (2) to investigate the influence of perceived usefulness and attitude on students' behavioral intention and actual use of AI-assisted music teaching, and (3) to examine the influence of perceived usefulness and actual use of AI-assisted music teaching on students' learning outcomes. This study employed a quantitative research approach, collecting data through an online questionnaire using purposive sampling combined with convenience and random sampling from 511 valid university students majoring in music from multiple universities across different regions of China who had experience with or exposure to AI-assisted music teaching tools. The analysis included descriptive statistics, measurement model evaluation, and structural model evaluation using partial least squares structural equation modeling to test the proposed hypotheses. Major findings: (1) on the influence of facilitating conditions and perceived ease of use, the results showed that facilitating conditions significantly influenced perceived ease of use and perceived usefulness, while perceived ease of use significantly influenced perceived usefulness and students' attitudes toward AI-assisted

music teaching; (2) on the influence of perceived usefulness and attitude, the results showed that perceived usefulness significantly influenced attitude and behavioral intention, while attitude significantly influenced behavioral intention and behavioral intention significantly influenced actual use of AI-assisted music teaching; and (3) on the influence of perceived usefulness and actual use on learning outcomes, the results showed that perceived usefulness and actual use both significantly influenced students' learning outcomes.

Keywords: Artificial intelligence-assisted music teaching, learning outcomes, Technology Acceptance Model, Constructivist Learning Theory, university students, music education

1.Introduction

Artificial intelligence (AI) has become an important driving force in educational transformation by supporting personalized learning, adaptive instruction, intelligent feedback, and data-driven learning environments (Wang et al., 2024). With the rapid development of machine learning, natural language processing, and intelligent recommendation systems, AI technologies are increasingly being integrated into various educational contexts. These technologies enable students to access learning materials more flexibly and receive immediate feedback that supports individualized learning (Lee et al., 2025). In music education, AI-assisted teaching can provide real-time performance evaluation, personalized learning content, adaptive practice activities, and intelligent instructional support, which may enhance students' engagement, motivation, and learning outcomes. Compared with traditional teacher-centered music instruction, AI-assisted music teaching offers more opportunities for continuous practice and individualized learning experiences (Mohd Amin et al., 2025). However, the effectiveness of AI-assisted music teaching depends not only on the availability of technology but also on students' acceptance and actual use of these technologies. Factors such as facilitating conditions, perceived

ease of use, perceived usefulness, attitude, behavioral intention, and actual use significantly influence students' learning outcomes in technology-enhanced learning environments (Du, 2025).

Existing studies mainly focus on the technical applications and functional advantages of AI in music education, while limited attention has been given to the mechanisms through which AI influences students' learning outcomes (Liang & Reiss, 2025). In addition, previous research often examines technology acceptance and learning outcomes separately, and student-centered empirical evidence remains insufficient (Novak et al., 2023). Some studies emphasize creativity enhancement and intelligent learning systems, but few studies integrate technology acceptance variables with learning outcomes within a comprehensive theoretical framework. Therefore, this study integrates the Technology Acceptance Model and Constructivist Learning Theory to examine how facilitating conditions, perceived ease of use, perceived usefulness, attitude, behavioral intention, and actual use influence students' learning outcomes in AI-assisted music teaching (Chen et al., 2025).

This study has both theoretical and practical significance. Theoretically, it extends the Technology Acceptance

Model by linking technology acceptance variables with learning outcomes and contributes to constructivist learning theory in technology-enhanced music education (Niu, 2026). Practically, the findings may help educators, educational institutions, and AI system developers improve AI-assisted music teaching and create more effective learning experiences (Nuryakin et al., 2023). A quantitative research design was adopted using a structured questionnaire distributed to university students with experience in AI-assisted music teaching (Cabellos et al., 2024). Data were analyzed using Structural Equation Modeling to test the proposed relationships among variables. This study was limited to university students and focused only on selected variables within the proposed framework.

2. Literature Review

2.1 Research context

Artificial intelligence (AI) has become an important driver of educational transformation, especially in higher education, through personalized learning, adaptive instruction, and intelligent feedback systems (Schmidt et al., 2025). International organizations such as UNESCO and OECD have emphasized that AI technologies can improve teaching effectiveness, learning flexibility, and student engagement in digital learning environments (Chigbu & Makapela, 2025). In higher education, AI applications such as intelligent tutoring systems, adaptive learning platforms, and automated assessment tools provide personalized learning support and continuous feedback, which contribute to improved learning outcomes (Maamor et al., 2024). However, the effectiveness of AI-assisted learning depends not only on technology availability but also on students' acceptance, perceptions, and actual usage behaviors (Létourneau et al., 2025).

In music education, AI technologies are increasingly applied in performance evaluation, ear training, music composition, and interactive learning environments (Ma, 2025). AI-assisted music learning systems can analyze students' performance data and provide adaptive learning content and real-time feedback, which help students improve musical skills more efficiently (Mustofa et al., 2025). Studies have shown that AI-supported music learning can enhance students' self-efficacy, learning engagement, and performance outcomes (Tan et al., 2025). In addition, AI-based composition and music generation tools encourage creativity and support constructivist learning by promoting active knowledge construction and exploration of musical ideas (Chen & Sun, 2024).

China has also actively promoted the integration of artificial intelligence into higher education through national strategies such as the "New Generation Artificial Intelligence Development Plan" and the "Smart Education of China" initiative (Ou et al., 2025). Chinese universities increasingly adopt AI technologies in teaching, learning analytics, and personalized learning environments to improve teaching quality and student performance (Zhu, 2026). However, challenges such as insufficient infrastructure, limited technical support, and students' perceptions of usefulness and ease of use continue to influence the effectiveness of AI-assisted learning (Ruano-Borbalan, 2025).

For university music students, AI-assisted learning provides flexible practice opportunities, personalized instruction, and continuous feedback beyond traditional classroom settings (Bognár & Khine, 2025). However, students' attitudes, behavioral intention, and actual use significantly influence whether AI-assisted music education

can improve learning outcomes (Cheng, 2025). Therefore, this study applies the Technology Acceptance Model and Constructivist Learning Theory to examine how Chinese university music students accept and use AI-assisted music teaching and how these factors influence their learning outcomes.

2.2 Parent Disciplines

2.2.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), is widely used to explain individuals' acceptance of new technologies (Herington et al., 2026). TAM proposes that perceived usefulness and perceived ease of use influence users' attitudes, behavioral intentions, and actual use of technology (Fortuna et al., 2025). Specifically, perceived usefulness refers to the degree to which individuals believe that using a particular system will enhance their performance, while perceived ease of use refers to the degree to which they believe that using the system will be free of effort. These two core constructs jointly shape users' cognitive evaluations, which subsequently determine their affective responses and behavioral decisions toward technology adoption. Recent studies confirm that these factors significantly affect students' acceptance of AI-assisted learning systems (Huang, 2024), particularly in higher education contexts where digital learning tools are increasingly prevalent.

Extended TAM models further incorporate additional variables such as facilitating conditions, attitude, and actual use to better explain technology adoption in educational settings (Zhu, 2024). Facilitating conditions highlight the importance of external support, including institutional resources, technical infrastructure, and guidance, which can significantly influence users'

perceived ease of use and perceived usefulness. These extensions provide a more comprehensive understanding of technology acceptance behavior, especially in complex learning environments where multiple contextual factors interact.

Therefore, this study applies TAM to examine students' acceptance of AI-assisted music teaching and its influence on learning outcomes. By integrating both core and extended TAM constructs, the study aims to provide a more holistic explanation of how students perceive, adopt, and utilize AI-based music learning systems. To address these limitations, this study applies TAM to examine students' acceptance of artificial intelligence-assisted music teaching and its influence on learning outcomes. As shown in Figure 2.1.

2.2.2 Constructivist Learning Theory

Constructivist learning theory explains that learners actively construct knowledge through interaction, experience, and reflection rather than passively receiving information (Davis et al., 1989). From this perspective, learning is viewed as an active and dynamic process in which students interpret new information based on prior knowledge, engage in meaningful learning tasks, and continuously refine their understanding through social and contextual engagement. The theory emphasizes key principles such as active learning, collaboration, contextual learning, and learner autonomy, all of which contribute to improved learning outcomes in technology-enhanced environments (Do et al., 2023). In particular, constructivism highlights that knowledge construction is most effective when learners are placed in authentic learning situations that encourage exploration, problem-solving,

and reflective thinking.

Artificial intelligence-assisted learning environments strongly support these constructivist principles by providing personalized feedback, adaptive learning content, and interactive learning experiences (Shan et al., 2025). AI systems can simulate real-time instructional guidance, adjust learning difficulty based on learner performance, and offer continuous performance evaluation, thereby creating a more individualized and learner-centered educational environment. In addition, AI tools enable students to repeatedly practice and refine their skills at their own pace, which is especially important in skill-based disciplines such as music education. In music learning contexts, AI-assisted teaching promotes independent practice, immediate feedback on performance accuracy, and iterative improvement, all of which enhance students' ability to construct musical knowledge actively rather than relying solely on teacher instruction (Doolittle et al., 2023).

Therefore, this study integrates constructivist learning theory with TAM to provide a more comprehensive explanation of students' learning outcomes in AI-assisted music teaching. This integration allows the research to examine not only how students accept and use AI technologies, but also how such usage facilitates active knowledge construction and ultimately improves learning performance in music education contexts.

2.3 Immediate Disciplines

This study examines key TAM constructs including facilitating conditions, perceived ease of use, perceived usefulness, attitude, behavioral intention, and actual use in explaining students' acceptance of AI-assisted music teaching (Venkatesh

et al., 2003). Within this framework, facilitating conditions refer to the availability of technical infrastructure, institutional support, and learning resources that enable effective system use. Perceived ease of use reflects the degree to which students believe that using AI-assisted music teaching requires minimal effort, while perceived usefulness represents their belief that such systems can enhance learning efficiency and performance outcomes. These cognitive evaluations jointly shape students' affective responses, particularly their attitudes toward AI-assisted music teaching. A positive attitude subsequently strengthens behavioral intention, which in turn serves as a direct antecedent of actual system usage. Prior research confirms that perceived ease of use and perceived usefulness significantly influence both attitude and intention, while behavioral intention is a strong predictor of actual use behavior (Fokides & Daskalou, 2026).

From a constructivist learning perspective, learning outcomes are understood as the result of active, interactive, and contextual knowledge construction processes, rather than passive knowledge reception (Haleem et al., 2022). In AI-assisted music education environments, students engage in continuous practice, receive immediate feedback, and adjust their performance through iterative learning cycles, which collectively enhance knowledge construction and skill development. AI technologies further support this process by enabling personalized learning pathways and adaptive instructional support (Mhlongo et al., 2023).

By integrating both TAM and constructivist learning theory, this study explores how students' cognitive perceptions, behavioral intentions, and actual usage of AI-assisted music

teaching systems collectively influence their learning outcomes in music education contexts (Caratiquit & Caratiquit, 2022). This integrated perspective provides a more comprehensive understanding of the mechanism linking technology acceptance to educational effectiveness.

2.4 Theoretical Framework and

2.5 Research Hypotheses

Based on the theoretical foundations of the Technology Acceptance Model, the Unified Theory of Acceptance and Use of Technology, and constructivist learning theory, this study develops a conceptual framework to examine how facilitating conditions, perceived ease of use, perceived usefulness, attitude, intention, and actual use of AI-assisted music teaching influence students' learning outcomes. The Technology Acceptance Model provides a useful explanation of how learners form beliefs about new educational technologies and how these beliefs shape their attitudes and behavioral intentions. In the context of AI-assisted music teaching, students do not merely evaluate whether a technology is available; rather, they assess whether the technology is understandable, useful, accessible, and relevant to their learning needs. Therefore, perceived ease of use and perceived usefulness are central psychological mechanisms through which students develop acceptance of AI-based learning tools.

At the same time, the Unified Theory of Acceptance and Use of Technology emphasizes the importance

Hypothesis development

The conceptual framework integrates TAM and constructivist learning theory to explain AI-assisted music teaching effects on learning outcomes. Facilitating conditions influence perceived ease of use and usefulness (H1–H2). Perceived ease of use affects usefulness and attitude

of external support conditions in technology adoption. For university music students, the successful use of AI-assisted music teaching depends not only on individual willingness but also on the availability of digital infrastructure, institutional guidance, teacher support, platform stability, and learning resources. These facilitating conditions are particularly important in music education because music learning often involves practice, feedback, creativity, performance, and technical skill development. If students lack access to appropriate devices, software, internet connectivity, or instructional guidance, the potential benefits of AI-assisted learning may not be fully realized. Therefore, this study incorporates facilitating conditions as an important external antecedent of students' perceptions and acceptance of AI-assisted music teaching.

Constructivist learning theory further supports the proposed framework by emphasizing that learning outcomes are shaped through active participation, interaction, reflection, and knowledge construction. AI-assisted music teaching provides students with opportunities to engage in personalized practice, receive

immediate feedback, explore musical ideas, and construct knowledge through repeated interaction with intelligent systems. In this sense, AI does not simply function as a technical tool; it can also serve as a learning environment that supports students' active engagement, self-regulated learning, and creative exploration. Therefore, the integration of TAM, UTAUT, and constructivist learning theory provides a more comprehensive explanation of how students' technology acceptance can be transformed into actual use and, ultimately, improved learning outcomes.

Facilitating conditions represent the extent to which students perceive that adequate technical infrastructure, institutional support, and instructional resources are available to support their use of AI-assisted music teaching systems. In AI-assisted music teaching, facilitating conditions may include access to intelligent music platforms, digital composition tools, AI-based accompaniment systems, online practice applications, automatic feedback systems, and teacher-provided guidance on how to use these tools effectively. When learners have access to stable devices, reliable internet connectivity, timely technical assistance, and sufficient instructional guidance, they are more likely to perceive the system as easy to use (Xia & Guo, 2025). This reflects the role of external support in reducing operational barriers and enhancing users' perceived control over technology usage. For music students, such support is especially important because AI-based music tools may involve multiple functions, such as pitch recognition, rhythm correction, music

generation, score analysis, and performance evaluation. Without sufficient support, students may experience confusion or anxiety when interacting with these systems. Therefore:

H1: Facilitating conditions positively influence perceived ease of use.

Facilitating conditions also play an important role in shaping students' perceptions of the usefulness of AI-assisted music teaching (Jiang et al., 2025). When institutional and technical support is sufficient, students are better able to experience the functional benefits of the learning system, such as improved efficiency and learning effectiveness. In music education, the usefulness of AI-assisted teaching may be reflected in more accurate practice feedback, more flexible learning resources, more efficient skill correction, and more individualized learning paths. For example, students may perceive AI-assisted tools as useful when these tools help them identify performance mistakes, improve music theory understanding, practice independently, or enhance creative composition. As a result, they are more likely to recognize the technology as valuable for their academic performance. Therefore:

H2: Facilitating conditions positively influence perceived usefulness.

Perceived ease of use refers to students' belief that AI-assisted music teaching is simple to operate and requires minimal effort. When students experience fewer difficulties in using the system, they can focus more on learning content rather than technical issues (Dou

& Feng, 2025). This is particularly relevant in music learning because students need to devote considerable cognitive and emotional resources to listening, performing, interpreting, and creating music. If the technology is complicated, students may shift their attention away from musical learning and become occupied with operational problems. By contrast, when AI-assisted music teaching tools are intuitive, clear, and responsive, students are more likely to experience them as supportive rather than burdensome. This improved learning experience enhances their ability to recognize the system's benefits, leading to stronger perceptions of usefulness. Therefore:

H3: Perceived ease of use positively influences perceived usefulness.

Perceived ease of use also influences students' attitudes toward AI-assisted music teaching. When learners find the system easy to use, they tend to feel more confident and less cognitively burdened during learning activities(Maričić et al., 2025). In music education, confidence is an important factor because students often face performance pressure, technical challenges, and emotional sensitivity in the learning process. If AI-assisted tools are perceived as easy to operate, students may feel that the technology can support their learning autonomy rather than increase their burden. This positive experience contributes to more favorable evaluations of the technology, while difficult systems may generate frustration and reduce acceptance. Therefore:

H4: Perceived ease of use

positively influences attitude toward AI-assisted music teaching.

Perceived usefulness reflects the degree to which students believe that AI-assisted music teaching improves their learning performance(Davis et al., 1989). In this study, perceived usefulness is not limited to general academic efficiency; it also refers to students' belief that AI-assisted music teaching can help them improve musical skills, deepen understanding, strengthen practice quality, and enhance learning confidence. When students recognize clear benefits such as better understanding, improved efficiency, and enhanced academic achievement, they are more likely to develop positive attitudes toward using the system. This is because students tend to evaluate educational technologies more favorably when they perceive a direct connection between technology use and meaningful learning gains. Therefore:

H5: Perceived usefulness positively influences attitude toward AI-assisted music teaching.

Perceived usefulness is also a key determinant of students' intention to use AI-assisted music teaching. When learners believe that the technology can effectively enhance their learning outcomes, they are more motivated to adopt and continuously use it in their study process(Otto et al., 2024). In the context of music learning, students' intention to use AI-assisted tools may be strengthened when they believe that such tools can help them practice more efficiently, receive more timely feedback, and improve their performance or creative output. Therefore, perceived

usefulness serves as a motivational belief that encourages students to move from positive evaluation to future use intention. Therefore:

H6: Perceived usefulness positively influences intention to use AI-assisted music teaching.

Attitude toward AI-assisted music teaching refers to students' overall evaluation of using AI technologies in music learning. When students hold positive attitudes toward the system, they are more likely to express willingness to use it in their learning activities(Liang & Reiss, 2025). A positive attitude may arise from students' belief that AI-assisted music teaching is interesting, innovative, helpful, and compatible with their learning habits. In contrast, negative attitudes may reduce their intention to adopt the technology. For example, students who perceive AI-assisted music teaching as impersonal, difficult, or irrelevant may be less willing to integrate it into their daily learning. Therefore:

H7: Attitude toward AI-assisted music teaching positively influences intention to use AI-assisted music teaching.

Intention to use AI-assisted music teaching reflects students' willingness to adopt AI-based learning tools, which directly leads to actual usage behavior(Alshammari et al., 2025). Students with stronger behavioral intentions are more likely to actively engage with AI-assisted learning systems and participate in learning activities consistently. This relationship is important because intention represents a bridge between psychological acceptance and behavioral

implementation. In other words, students may perceive AI-assisted music teaching as useful and hold positive attitudes toward it, but actual learning improvement is more likely to occur when such intention is transformed into regular and meaningful use. Therefore:

H8: Intention to use AI-assisted music teaching positively influences use of AI-assisted music teaching.

Use of AI-assisted music teaching refers to students' actual engagement with AI technologies during music learning activities(Wiyono et al., 2025). Actual use may include practicing with AI feedback systems, using AI tools for music analysis, interacting with intelligent tutoring platforms, generating or revising musical materials, and receiving personalized learning support. From the perspective of constructivist learning theory, students' learning outcomes are enhanced when they actively interact with learning environments and construct knowledge through experience. When students actively interact with these systems, they are more likely to construct knowledge effectively through participation and experience, which enhances their academic performance and learning outcomes. Therefore:

H9: Use of AI-assisted music teaching positively influences students' learning outcomes.

Perceived usefulness also has a direct impact on students' learning outcomes(Maamor et al., 2024). When learners perceive AI-assisted music teaching as beneficial, they are more likely to invest effort and engage meaningfully in learning tasks(Wiyono et al., 2025). This increased engagement

supports knowledge construction and ultimately improves academic performance. In addition, students who perceive AI-assisted music teaching as useful may develop stronger learning motivation, greater confidence, and more active self-regulation. These psychological and behavioral responses may help them benefit from AI-assisted teaching even beyond actual usage frequency. Therefore:

H10: Perceived usefulness positively influences students' learning outcomes.

As shown in Table 1, the hypotheses developed in this study are systematically presented, outlining the proposed relationships among facilitating conditions, perceived ease of use, perceived usefulness, attitude, behavioral intention, actual use, and students' learning outcomes in the context of AI-assisted music teaching.

3. Research Methodology

3.1 Research Design

This study adopts a positivist research paradigm and a quantitative research design to systematically examine the relationships among key constructs in AI-assisted music teaching and students' learning outcomes. The positivist paradigm is appropriate as it emphasizes objective measurement, hypothesis testing, and statistical analysis of observable variables (Park et al., 2019). Accordingly, this study applies a cross-sectional survey method to collect empirical data from students, enabling the examination of relationships among facilitating conditions, perceived ease of use, perceived usefulness, attitude toward

Overall, the proposed framework suggests that AI-assisted music teaching influences learning outcomes through both technological acceptance and learning engagement mechanisms. Facilitating conditions provide the external support necessary for students to access and operate AI-based learning systems; perceived ease of use and perceived usefulness shape students' cognitive evaluations of the technology; attitude and intention reflect their psychological acceptance; and actual use represents the behavioral pathway through which AI-assisted music teaching contributes to learning improvement. By integrating technology acceptance and constructivist learning perspectives, this study offers a structured explanation of how AI-assisted music teaching can support students' academic development in higher music education.

AI-assisted music teaching, intention to use, actual use behavior, and learning outcomes.

A structured questionnaire is used as the primary data collection instrument, and the research hypotheses are developed based on the Technology Acceptance Model and Constructivist Learning Theory. The deductive approach is adopted to test the proposed theoretical model using empirical data (Casula et al., 2021). Structural Equation Modeling (SEM) is employed to analyze both measurement and structural relationships among variables, allowing for simultaneous testing of multiple hypotheses. Overall, this quantitative research design ensures rigorous hypothesis testing and provides

empirical evidence to validate the proposed conceptual framework.

3.2 Research Tools

The primary data collection instrument of this study is a structured questionnaire designed based on well-established measurement scales from prior research, with appropriate modifications to fit the context of AI-assisted music teaching. The questionnaire adopts a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), which is widely used in social science research for its simplicity, reliability, and effectiveness in capturing respondents' perceptions and attitudes.

The questionnaire consists of two sections. The first section collects respondents' demographic information, while the second section measures the key latent constructs of the study, including facilitating conditions, perceived ease of use, perceived usefulness, attitude toward AI-assisted music teaching, intention to use AI-assisted music teaching, use of AI-assisted music teaching, and students' learning outcomes.

Each construct is operationalized using validated multi-item scales adapted from previous studies to ensure content validity and conceptual consistency. Specifically, facilitating conditions are measured in terms of resource availability, knowledge, compatibility, and technical support (Ghanad, 2023). Perceived ease of use and perceived usefulness are adapted from the Technology Acceptance Model (Davis, 1989), focusing on accessibility, effort, and learning effectiveness (Ou et al., 2025). Attitude toward AI-assisted music teaching reflects learners' overall evaluation of AI in music learning, while intention to use and actual use capture behavioral readiness and engagement (Campbell et al., 2020).

Students' learning outcomes are measured based on perceived learning effectiveness, improvement, and learning experience quality (Campbell et al., 2020).

All items are measured using a five-point Likert scale, ensuring consistency across constructs and enabling quantitative analysis through statistical techniques such as structural equation modeling. This design ensures reliability, validity, and comparability of the measurement model.

3.3 Sampling and Data Collection

This study targets university students majoring in music from different regions of China who have experience with AI-assisted music teaching. This population is appropriate because AI technologies are increasingly integrated into higher education, especially in skill-based disciplines such as music, where personalized instruction and continuous feedback are essential (Memon et al., 2020).

A purposive sampling technique was adopted to ensure respondents had relevant experience with AI-assisted learning tools. In addition, convenience sampling was used to recruit participants from accessible universities, improving data collection efficiency while maintaining relevance. This combined approach is widely used in educational technology research (Wolf et al., 2013).

The minimum sample size was calculated based on the 15:1 item-to-response ratio for structural equation modeling. With 27 measurement items, at least 405 responses were required. A total of 511 valid questionnaires were collected, meeting the recommended requirement and ensuring statistical reliability (Wu et al., 2022).

Data were collected through an online questionnaire distributed via university platforms and social media applications such as WeChat and QQ.

Screening questions ensured respondents met inclusion criteria. After removing invalid responses, the final dataset was used for further quantitative analysis.

3.4 Data Analysis

The quantitative data in this study were analyzed using SPSS and SmartPLS to ensure accuracy, reliability, and robustness of the empirical results. A systematic multi-step procedure was adopted, including descriptive statistical analysis, measurement model evaluation, and structural model analysis. This approach is consistent with Partial Least Squares Structural Equation Modeling (PLS-SEM), which is widely used in educational technology research for testing complex relationships among latent variables (Al-Hail et al., 2023).

3.4.1 Descriptive Statistical Analysis

Descriptive statistical analysis was conducted to summarize respondents' demographic characteristics, including gender, age, year of study, and exposure to AI-assisted music teaching. This provides an overall profile of the sample and ensures its suitability for the research objectives.

In addition, mean and standard deviation were calculated to describe the distribution of key constructs, including facilitating conditions, perceived ease of use, perceived usefulness, attitude toward AI-assisted music teaching, intention to use, actual use, and students' learning outcomes. Mean values indicate the overall level of agreement, while standard deviation reflects response variability. This step also helps identify data distribution patterns and ensures suitability for further SEM analysis.

Overall, descriptive statistical analysis provides essential background information and serves as the foundation for subsequent measurement and structural model evaluation.

3.4.2 Measurement Model

The measurement model was

evaluated to ensure the reliability and validity of the constructs before hypothesis testing. In this study, internal consistency reliability was assessed using Cronbach's alpha and composite reliability (CR). Values above 0.70 indicate acceptable reliability (Shea et al., 2022).

Convergent validity was examined using factor loadings and average variance extracted (AVE). Factor loadings above 0.70 and AVE values above 0.50 indicate adequate convergence. Discriminant validity was assessed using the Fornell–Larcker criterion and the heterotrait–monotrait ratio (HTMT), where HTMT values below 0.90 confirm construct distinctiveness (Cooksey, 2020).

These procedures ensure that all measurement scales used in this study are both reliable and valid for further structural analysis.

3.4.3 Structural Model

After validating the measurement model, the structural model was analyzed to test the hypothesized relationships among constructs. Path coefficients were estimated using SmartPLS, and their significance was assessed through bootstrapping with 5,000 resamples. A p-value below 0.05 indicates a statistically significant relationship (Hair et al., 2021).

In addition, the coefficient of determination (R^2) was used to evaluate the explanatory power of the model, while effect size (f^2) assessed the contribution of each predictor. Predictive relevance (Q^2) was examined using the blindfolding procedure, where values greater than zero indicate acceptable predictive capability.

Overall, the structural model analysis provides empirical evidence for testing all hypotheses and evaluating the explanatory strength of the proposed research model on AI-assisted music teaching and students' learning

outcomes.

4. Results

4.1 Descriptive Statistics

A total of 511 valid responses were obtained and included in the final analysis, providing a sufficient sample size for subsequent statistical analysis. The demographic characteristics of the respondents are presented in Table 2. Among the participants, 58.1% were female and 41.9% were male, indicating a relatively balanced gender distribution, which enhances the representativeness of the sample and reduces potential gender bias.

In terms of age distribution, the majority of respondents were between 21 and 23 years old (46.6%), followed by those aged 18–20 (30.5%). This indicates that the sample primarily consists of undergraduate students in their early academic stages, who are generally more familiar with digital technologies and more likely to engage with AI-assisted learning tools.

Regarding academic level, respondents were distributed across different years of study, with junior students (26.6%) accounting for the largest proportion, followed by sophomores (23.7%) and seniors (23.1%). This relatively balanced

distribution across academic levels enhances the diversity of the sample and improves its representativeness.

In terms of institutional background, participants were drawn from comprehensive universities (31.7%), normal universities (34.8%), and music or art universities (33.5%), indicating a well-balanced institutional representation. This diversity ensures that the findings are not limited to a single type of higher education institution.

Regarding the frequency of using AI-assisted music teaching, most respondents reported using it often (35.4%) or sometimes (30.9%), suggesting that the majority of participants had practical experience with AI-assisted learning tools. This ensures that respondents are capable of providing informed evaluations of the study constructs.

Overall, the demographic characteristics indicate that the sample is appropriate and sufficiently diverse for examining the influence of AI-assisted music teaching on students' learning outcomes. As shown in Table 2, the demographic profile of respondents is presented.

4.2 Measurement Model

The measurement model was evaluated by examining indicator reliability, internal consistency reliability, and convergent validity. The results show that the outer loadings of all items ranged from 0.708 to 0.846, exceeding the recommended threshold of 0.70, indicating satisfactory indicator reliability. Internal consistency reliability was assessed using Cronbach's alpha and composite reliability. The Cronbach's alpha values ranged from 0.745 to 0.824, while composite reliability values ranged from 0.839 to 0.884, all of which are above

the recommended threshold of 0.70. These findings indicate that the measurement scales demonstrate good internal consistency. Convergent validity was further examined using average variance extracted (AVE). The AVE values ranged from 0.566 to 0.682, exceeding the acceptable threshold of 0.50, which confirms that each construct explains a sufficient proportion of variance in its indicators. Overall, the results confirm that the measurement model has satisfactory indicator reliability, internal consistency reliability, and convergent validity.

Discriminant validity was first

assessed using the Fornell–Larcker criterion to determine whether each construct is empirically distinct from the others. The results show that the square root of AVE for each construct is greater than its correlations with other constructs. For example, facilitating conditions show a higher square root of AVE than its correlations with other variables, and the same pattern is observed for perceived usefulness, perceived ease of use, attitude, behavioral intention, actual use, and learning outcomes. This indicates that each construct shares more variance with its own measurement items than with other constructs, confirming adequate discriminant validity and conceptual distinction among variables.

Discriminant validity was further examined using the heterotrait–monotrait (HTMT) ratio. The results indicate that all HTMT values fall below the recommended threshold of 0.90, ranging from 0.503 to 0.859. The highest value is observed between attitude toward AI-assisted music teaching and intention to use AI-assisted music teaching, but it remains within the acceptable range. These findings further confirm that all constructs are empirically distinct and that there is no serious overlap among them. Overall, the results of both the Fornell–Larcker criterion and HTMT analysis demonstrate that the measurement model exhibits satisfactory discriminant validity, supporting the reliability and validity of the constructs used in this study.

4.3 Structural Model Analysis

he structural relationships.

The structural path analysis revealed that all hypothesized relationships were positive and statistically significant. Facilitating conditions were found to have a significant positive effect on perceived ease of use, indicating that when

learners perceive sufficient external support, resources, and learning conditions, they are more likely to find AI-assisted music teaching systems easy to use. Facilitating conditions also significantly influenced perceived usefulness, suggesting that a supportive learning environment enhances learners' evaluation of the practical value of AI-assisted instruction.

Perceived ease of use was found to significantly affect perceived usefulness, indicating that when learners find AI systems easy to operate, they are more likely to perceive them as useful for learning purposes. In addition, perceived ease of use also had a significant positive effect on attitude toward AI-assisted music teaching, demonstrating that system simplicity contributes to more favorable learner attitudes.

Perceived usefulness was identified as a key antecedent variable in the model. It significantly influenced attitude toward AI-assisted music teaching, indicating that learners who perceive AI tools as beneficial are more likely to develop positive attitudes toward their use. Perceived usefulness also had a significant positive effect on intention to use AI-assisted music teaching, suggesting that perceived practical benefits directly motivate learners' willingness to adopt AI tools. Furthermore, perceived usefulness significantly influenced students' learning outcomes, indicating that learners who perceive higher utility from AI systems tend to achieve better academic performance.

Attitude toward AI-assisted music teaching was also found to be a strong predictor of behavioral intention. The results show that learners with more positive attitudes toward AI-assisted tools are more likely to intend to use them in their learning process. In turn, behavioral intention significantly

influenced actual use of AI-assisted music teaching, confirming that intention plays a crucial role in translating psychological willingness into real behavioral engagement.

Finally, actual use of AI-assisted music teaching was found to have a significant positive impact on students' learning outcomes. This indicates that frequent and active engagement with AI-supported learning tools contributes directly to improved learning performance in music education. Overall, all hypothesized relationships were supported, confirming the robustness of the proposed structural model.

The explanatory power of the model was further examined using the coefficient of determination (R^2). The results showed that facilitating conditions explained 30.0% of the variance in perceived ease of use, indicating a moderate explanatory effect. When combined with perceived ease of use, facilitating conditions explained 44.2% of the variance in perceived usefulness, demonstrating that both environmental support and system usability jointly contribute to learners' perceived value of AI tools.

Perceived ease of use and perceived usefulness together explained 48.6% of the variance in attitude toward AI-assisted music teaching, indicating that learners' attitudes are largely shaped by their perceptions of usability and usefulness. Furthermore, perceived usefulness and attitude jointly explained 53.8% of the variance in behavioral intention, suggesting that cognitive evaluation and affective response together play a strong role in shaping learners' willingness to use AI-assisted systems.

Behavioral intention explained 37.3% of the variance in actual use behavior, indicating that intention is a meaningful but not exclusive predictor of real system usage. Finally, perceived

usefulness and actual use jointly explained 41.7% of the variance in students' learning outcomes, suggesting that both cognitive evaluation and behavioral engagement contribute to academic performance improvements. Overall, the model demonstrates moderate explanatory power across all endogenous variables.

The effect size (f^2) analysis further clarified the relative contribution of each predictor variable. Facilitating conditions had a large effect on perceived ease of use, indicating that external support plays a critical role in shaping learners' perceptions of system usability. However, its effect on perceived usefulness was small, suggesting that its influence is more indirect.

Perceived ease of use had a medium effect on perceived usefulness, confirming that usability plays an important role in shaping perceived value. Its effect on attitude was relatively small, indicating a weaker but still meaningful influence. Perceived usefulness had a medium effect on attitude and a small effect on behavioral intention, highlighting its central but indirect role in shaping learner motivation.

Attitude toward AI-assisted music teaching had a large effect on behavioral intention, emphasizing its strong motivational role in determining learners' willingness to use AI tools. Behavioral intention had a large effect on actual use, confirming its critical role in translating intention into behavior. In addition, both perceived usefulness and actual use showed medium effects on students' learning outcomes, indicating that both perception and behavior contribute meaningfully to academic performance.

The predictive relevance of the model was assessed using the blindfolding procedure. All Q^2 values were greater than zero, indicating that

the model has adequate predictive relevance for all endogenous constructs. This suggests that the model is not only explanatory but also capable of predicting future data patterns effectively.

Finally, the overall structural model results confirm a coherent and sequential mechanism linking facilitating conditions, perceived ease of use, perceived usefulness, attitude, behavioral intention, actual use, and students' learning outcomes. Facilitating conditions and perceived ease of use indirectly influence learning outcomes through a chain of psychological and behavioral factors. Specifically, external support and system usability shape perceived usefulness, which then influences attitude and behavioral intention, ultimately leading to actual usage behavior and improved learning outcomes. This integrated pathway confirms the applicability of the Technology Acceptance Model in combination with learning theory in explaining AI-assisted music learning behavior.

4.4 Conclusion

The empirical results of the study examined the influence of AI-assisted music teaching on students' learning outcomes. First, descriptive statistical analysis was conducted to summarize respondents' demographic characteristics and the distribution of the study variables. The results indicated that the data were normally distributed and suitable for further analysis.

Next, the measurement model was assessed through reliability and validity analysis. The findings demonstrated satisfactory internal consistency, convergent validity, and discriminant validity, confirming that the measurement model was acceptable and the constructs were measured in a reliable and valid manner.

Subsequently, the structural model

was evaluated to test the proposed hypotheses. The results revealed that facilitating conditions significantly influenced perceived ease of use and perceived usefulness. In addition, perceived ease of use and perceived usefulness significantly affected students' attitudes toward AI-assisted music teaching. Furthermore, perceived usefulness and attitude toward AI-assisted music teaching significantly influenced students' intention to use AI-assisted music teaching. The findings also indicated that intention to use AI-assisted music teaching significantly affected actual use behavior. Finally, both the use of AI-assisted music teaching and perceived usefulness significantly influenced students' learning outcomes. Overall, all proposed hypotheses were supported, indicating that the conceptual framework of the study was well supported by the empirical data.

These findings provide empirical evidence for understanding the adoption of AI-assisted music teaching and its impact on students' learning outcomes. The results also offer a solid foundation for further discussion of theoretical and practical implications, which will be presented in the following section.

5. Discussion and Conclusions

This study presents the discussion and conclusions of the study on the influence of AI-assisted music teaching on students' learning outcomes. Based on the empirical findings, it discusses the relationships among facilitating conditions, perceived ease of use, perceived usefulness, attitude, behavioral intention, actual use, and learning outcomes. It further interprets the results in relation to the Technology Acceptance Model and Constructivist Learning Theory, and outlines their theoretical and practical implications. Finally, it addresses the study's limitations, provides suggestions for

future research, and summarizes the overall conclusions.

5.1 Theoretical Implications

This study contributes to existing literature by extending the Technology Acceptance Model (TAM) and Constructivist Learning Theory within the context of AI-assisted music teaching.

First, the study extends TAM by confirming the central roles of facilitating conditions, perceived ease of use, and perceived usefulness in shaping students' attitudes toward AI-assisted music teaching. The findings demonstrate that facilitating conditions significantly influence both perceived ease of use and perceived usefulness, while perceived ease of use further enhances perceived usefulness and attitude. Perceived usefulness also directly strengthens students' attitudes, behavioral intention, and learning outcomes. These results reinforce the core TAM assumption that external conditions and cognitive beliefs jointly shape technology acceptance. More importantly, this study extends TAM by linking acceptance variables directly to learning outcomes, rather than focusing only on behavioral intention.

Second, the study refines the internal mechanism of TAM in AI-assisted learning contexts. The results indicate that attitude plays a stronger role than perceived usefulness in predicting behavioral intention, suggesting that affective evaluation is particularly important in music education settings. This finding extends prior TAM applications by highlighting that emotional acceptance may serve as a stronger bridge between cognitive beliefs and behavioral intention in creative and skill-based learning environments such as music education.

Third, this study contributes to Constructivist Learning Theory by confirming that actual use of AI-assisted

music teaching significantly enhances students' learning outcomes. This supports the constructivist assumption that learning is strengthened through active engagement and interaction with learning tools. Importantly, the study extends constructivism by showing that knowledge construction is not only achieved through human interaction but also through interaction with AI systems. AI-assisted music tools provide real-time feedback, adaptive practice, and personalized learning support, which facilitate experiential learning and active knowledge construction.

Overall, this study integrates TAM and Constructivist Learning Theory into a unified framework that explains how technological perceptions lead to behavioral adoption and ultimately influence learning outcomes in AI-assisted music education.

5.2 Practical Implications

The findings provide practical implications for educators, institutions, and AI developers in music education.

For educators, the results highlight the importance of strengthening students' facilitating conditions by ensuring adequate technical support, training, and guidance in using AI-assisted music tools. Teachers should actively demonstrate how to use AI systems for tasks such as composition, pitch correction, rhythm training, and performance feedback. Such guidance can enhance students' perceived ease of use and perceived usefulness, thereby improving their attitudes and engagement.

Educators should also focus on enhancing system usability and learning integration. Since perceived ease of use strongly influences perceived usefulness and attitude, AI tools should be introduced in a structured and step-by-step manner. Teachers can reduce students' cognitive burden by providing tutorials, practice tasks, and

guided demonstrations, ensuring that AI tools become accessible and meaningful learning instruments.

For institutions, the findings emphasize the importance of building strong digital infrastructure and providing continuous technical support. Institutions should ensure stable access to AI-assisted music platforms and offer professional training programs for both teachers and students. A supportive institutional environment can significantly improve students' acceptance and actual use of AI-assisted music teaching systems.

For AI developers, the study highlights the need to improve usability, personalization, and educational functionality. Systems should provide real-time feedback, adaptive learning pathways, and user-friendly interfaces. In addition, integrating interactive features such as performance tracking and learning analytics can further enhance user engagement and learning effectiveness.

Overall, successful implementation of AI-assisted music teaching requires coordinated efforts among educators, institutions, and technology developers.

5.3 Limitations and Future Research

Several limitations should be acknowledged.

First, the study adopts a cross-sectional design, which limits the ability to establish causal relationships. Although significant relationships were identified, students' perceptions and behaviors may change over time with increased experience in AI-assisted music learning.

Second, the study relies on self-reported data, which may introduce response bias. Students' evaluations of their learning outcomes and technology use may not fully reflect actual behavior.

Third, the sample is limited to university students exposed to

AI-assisted music teaching, which may restrict generalizability to other populations such as secondary school students or professional musicians.

Fourth, although the model integrates key TAM and constructivist variables, other potential factors such as digital literacy, learning motivation, and prior musical experience were not included.

Finally, the study focuses on general AI-assisted music teaching rather than specific AI platforms, which may vary in functionality and effectiveness.

Future research should adopt longitudinal designs, expand sample diversity, include additional psychological and contextual variables, and explore different AI music learning systems. Mixed-method approaches such as interviews or case studies are also recommended to deepen understanding of learning processes.

5.4 Conclusion

This study examined the influence of AI-assisted music teaching on students' learning outcomes by integrating the Technology Acceptance Model and Constructivist Learning Theory. The findings indicate that facilitating conditions, perceived ease of use, perceived usefulness, attitude, behavioral intention, and actual use all play important roles in shaping learning outcomes.

Specifically, facilitating conditions enhance perceived ease of use and perceived usefulness, which in turn influence students' attitudes and behavioral intention. Behavioral intention significantly predicts actual use, and actual use, together with perceived usefulness, significantly improves learning outcomes. These results confirm that students' acceptance of AI-assisted music teaching is a key mechanism for improving learning performance.

The study extends TAM by linking acceptance factors to learning outcomes and enriches Constructivist Learning Theory by demonstrating the importance of active engagement with AI systems. It also provides practical guidance for improving AI-assisted music teaching implementation in higher education.

Despite certain limitations, this study offers valuable theoretical and practical insights into AI-assisted music teaching and provides a foundation for future research on AI-supported music education.

6. New Knowledge Contribution

First, it extends the traditional scope of TAM by moving beyond behavioral intention and actual use to include students' learning outcomes as a core dependent variable. While previous TAM-based studies have primarily focused on explaining technology acceptance behavior, this research demonstrates a complete causal chain from facilitating conditions to cognitive perceptions (perceived ease of use and perceived usefulness), then to affective response (attitude), behavioral response (intention and actual use), and ultimately to educational outcomes. This extension provides a more comprehensive explanatory model that connects technology acceptance directly with educational effectiveness, thereby enriching TAM's applicability in AI-enhanced learning environments.

Second, this study contributes to a more nuanced understanding of how AI-assisted music teaching functions in higher education by revealing the differentiated roles of cognitive and affective factors. The findings show that perceived usefulness not only directly influences behavioral intention but also exerts a significant direct effect on learning outcomes, highlighting its dual pathway of influence. In contrast,

attitude plays a particularly strong mediating role between cognitive beliefs and behavioral intention, suggesting that emotional evaluation is especially critical in creative and performance-based disciplines such as music education. This insight refines existing TAM applications by emphasizing that in artistic learning contexts, emotional acceptance may be as important as functional evaluation in shaping technology adoption behavior.

Third, the study supports the constructivist view that knowledge is actively constructed through interaction and experience. However, this study extends the theory further by showing that knowledge construction is not limited to human-to-human or learner-to-environment interaction but also includes learner-to-AI interaction. AI systems provide adaptive feedback, real-time performance evaluation, and personalized learning pathways, which collectively facilitate iterative learning processes and deepen students' active knowledge construction. This finding expands the theoretical boundaries of constructivism in the context of intelligent and data-driven learning environments.

Finally, this research contributes a context-specific theoretical integration model for AI-assisted music education in non-Western higher education settings, particularly within Chinese university contexts. By incorporating facilitating conditions as a foundational external factor and linking them systematically with psychological and behavioral constructs, the study provides a structured explanation of how institutional support and technological infrastructure indirectly shape learning outcomes.

Appendix

Table 1 Hypothesis development statement

H1	Facilitating conditions positively influence perceived ease of use.
H2	Facilitating conditions positively influence perceived usefulness.
H3	Perceived ease of use positively influences perceived usefulness.
H4	Perceived ease of use positively influences attitude toward AI-assisted music teaching.
H5	Perceived usefulness positively influences attitude toward AI-assisted music teaching.
H6	Perceived usefulness positively influences intention to use AI-assisted music teaching.
H7	Attitude toward AI-assisted music teaching positively influences intention to use AI-assisted music teaching.
H8	Intention to use AI-assisted music teaching positively influences use of AI-assisted music teaching.
H9	Use of AI-assisted music teaching positively influences students' learning outcomes.
H10	Perceived usefulness positively influences students' learning outcomes.

Table 2. Demographic Profile of Respondents

Information and options	Frequency	Percent (%)
Gender		
Male	214	41.9
Female	297	58.1
Age		
18–20	156	30.5
21–23	238	46.6
24–26	92	18
Above 26	25	4.9
Year of Study		
Freshman	85	16.6
Sophomore	121	23.7
Junior	136	26.6

Senior	118	23.1
Postgraduate	51	10
Frequency of Using AI-assisted Music Teaching		
Rarely	72	14.1
Sometimes	158	30.9
Often	181	35.4
Very often	100	19.6
Total	511	100

(Source: Ma Long)

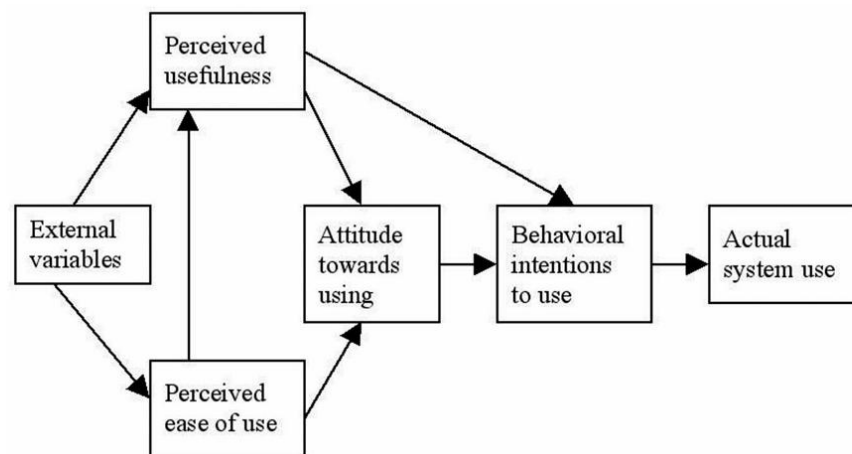


Figure 1. Conceptual Model of Digital Intelligence-Driven Personalized Learning

(Source: Davis et al. (1989))

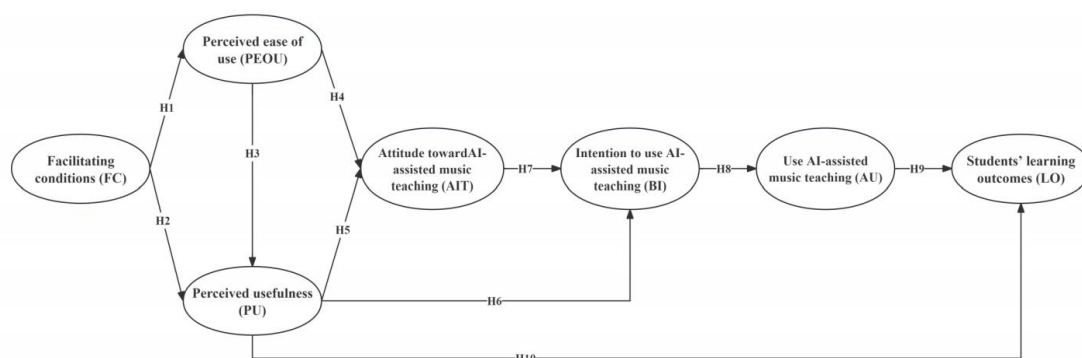


Figure 2. Conceptual framework

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